OBSERVATIONS MADE IN 1906 ON GLACIERS IN ALBERTA AND BRITISH COLUMBIA.

BY GEORGE, JR. AND WILLIAM S. VAUX.

At the present time the glaciers close to the line of the Canadian Pacific Railway located in the western part of Alberta and the eastern of British Columbia offer very convenient opportunities for study and comparison. The most accessible examples are found on the western slopes of the Selkirk and Rocky Mountain ranges, where they are fed by the immense precipitation from the warm winds blowing eastward from the Pacific Ocean. In common with almost all glaciers throughout the world it is found that these are receding, and while the changes between year and year are not great when the immense area of the glacier is considered, in a decade or century sweeping differences must be noted.

That the general tendency for a great many years has been to recede every glacier in this region points with unmistakable evidence. At no very remote date the Illecillewaet and Asulkan Glaciers met and flowed as one down the valley which is now shared in common by their streams; while the beautiful Lake Louise, more than 225 feet deep at the centre, owes its existence to the dying Victoria Glacier which now extends only to within one and one-half miles of the upper edge and is year by year depositing in the lake masses of glacier mud, ultimately to reduce it to a muskeg marsh. Thus at every turn the life span of glacier, mountain and lake may be read, and the creating and destroying forces seen at work on every hand.

The much greater activity of glaciers located on the western slopes of the mountains as compared with those on the eastern has already been noted, and it may also be observed that the snowfall on the higher ranges is greater than on the lower in corresponding positions, even though the latter may lie farther to the west, and consequently nearer to the origin of the moisture-bearing winds from the Pacific Ocean.

The amount of precipitation of snow on the several mountain slopes and in the passes adjacent to the railway has always been a matter of much interest to those concerned in protecting the roadbed during the winter, and also to students of glacier and alpine phenomena, as by comparisons made over a long series of years interesting data of cause

and effect may be obtained. Upon the completion of the railway records were started, and have been kept with more or less regularity, of the snowfall at three points near the summit of Roger's Pass on the western slope of the Selkirk Range. While of course great variations have taken place and inaccuracies have crept in, the summaries of daily measurements are here given as they have been preserved for three stations, "Cut Bank," at an elevation of about 4,000 feet, Glacier House, 4,120 feet, and "No. 18 Shed," 4,300 feet.

Table Showing Yearly Snowfall on West Slope of Selkirk Range.

Year.	Cut Bank.	Glacier House.	No. 18 Shed.
1886–1887	No record.	No record.	42 ft. 0 ins.
1887–1888	No record.	No record.	34 " 0 "
1888–1889	14 ft. 5 ins.	No record.	28 " 0 "
1889–1890	20 " 9 "	No record.	33 " 3 "
1890–1891	17 " 6 "	No record.	No record.
1891–1892	21 " 9 "	No record.	36 ft. 3 ins.
1892–1893	23 " 11 "	No record.	38 " 10 "
1893–1894	23 " 9 "	45 ft. 4½ ins.	No record.
1894–1895	16 " 4 "	28 " 11 "	No record.
1895–1896	27 " 8 "	No record.	No record.
1896–1897	10 " 2 "	34 ft. 11 ins.	No record.
1897–1898	No record.	27 " 6 "	No record.
1898–1899	18 ft. 11 ins.	43 " 2 "	No record.
1899–1900	18 " 10 "	26 " 9 "	20 ft. 0 ins.
1900–1901	17 " 10 "	32 " 1 "	34 " 11 "
1901–1902	19 " 3 "	28 " 6½ "	30 " 1 "
1902–1903	22 " 11 "	32 " 0 "	28 " 9 "
1903–1904	24 " 1 "	31 " 11 "	41 " 4 "
1904–1905	15 " 1 "	16 " 7 "	14 " 8¾ "
1905–1906	14 " 3 "	22 " 0¼ "	22 " 4½ "

Taking into account only the years in which records have been preserved gives the average snowfall at "Cut Bank," 19 feet 3 inches, Glacier House, 30 feet 10 inches, and "No. 18 Shed," 33 feet 8 inches, while the average yearly snowfall, taking into account all years observed since the winter of 1886, gives 27 feet 11 inches. On the higher slopes and the névé regions of the glaciers in the vicinity the snowfall is much greater, yet the above may be taken fairly as an average for the elevation of Glacier House, 4,120 feet, or a little below the tongue of the Illecillewaet Glacier.

In the following pages no attempt will be made to describe the peculiar phenomena of the several glaciers upon which measurements have been made, but to briefly outline the observations made during the last two weeks of July, 1906, together with sufficient description of the work which has gone before to provide data for comparisons.

Illecillewaet Glacier.

Glacier House, British Columbia.

Being the most accessible of any of this group, the Illecillewaet Glacier has been observed yearly since 1898. Prior to that time, beginning in 1887, the observations have been made with less regularity.[1]

The work may be divided under three heads, each of which will be treated separately as follows:

Test Pictures.—These have been made each year, beginning August 17, 1898, from the marked rock "W." From this point a complete view of the tongue and lower glacier may be had, and of a part of the icefall almost up to the limit of the dry glacier. The same camera and lens being used and exactly the same position selected, the pictures indicate very accurately the changes which have taken place in any given interval. A careful study of these shows that in spite of the continued recession of the tongue and a general shrinkage of the ice at the edges, particularly at the left side where great masses have broken away uncovering water-worn bedrock, the thickness of the ice at the sky line is appreciably thicker than it was in 1898. This condition has been noted for a number of years, and time alone will prove whether an advance will take place when the thicker mass reaches the icefall and tongue. There is no doubt, however, that in all other particulars—breadth, depth and extension of tongue—the glacier is at present from year to year decreasing. A comparison of the two test pictures of 1902 and 1906, reproduced herewith, with that made in 1898 (compare Plate V, *Proc. Acad. Nat. Sci. Phila.*, 1899) will show in detail the changes which have taken place.

Recession of Tongue.—As previously noted (*Proc. Acad. Nat. Sci. Phila.*, 1899, p. 124), the first accurate location of the tongue of the ice is to be found in a long flat boulder not far from the moraine of 1887 (S. on the map), lettered by unknown hands, "16 feet to nearest ice, '90." With this rock as a basis the glacier showed a retreat after eight years on August 17, 1898, of 452 feet.

From 1898 to the past summer (1906) the annual change has been determined from a rock (marked "C." on map) lying in the centre of the bed moraine and which on August 17, 1898, was 60 feet from the tongue of the ice. The following table shows the recession each year and the date on which the measurements were made.

[1] For detailed accounts of previous investigations on this glacier see *Proc. Acad. Nat. Sci. Phila.*, 1899, pp. 121 and 501, and 1901, p. 213.

Illecillewaet Glacier, Recession of Tongue of Ice from Rock C.

Date of Observation.	Distance Tongue of Ice to Rock C.	Recession of Ice since previous Year.
Aug. 17, 1898	60 ft.	
July 29, 1899	76 "	16 ft.
Aug. 6, 1900	140 "	64 "
Aug. 5, 1901	155 "	15 "
Aug. 26, 1902	203 "	48 "
Aug. 25, 1903	235 "	32 "
Aug. 14, 1904	240½ "	5½ "
July 25, 1905	243 "	2½ "
July 24, 1906	327 "	84 "

It is interesting to note that while the recession between 1890 and 1898 showed an average of 56 feet per year, for the eight years from 1898 to 1906 this average has been but 33.3 feet per year, or about three-fifths. It will also be observed, by reference to the map, that the measurement on July 24, 1906, was not made to the point of greatest extension in the ice. Should this point have been measured the course would not have been in the same line as previous years, the tongue having moved to the left, but the recession for the year ending in 1906 would have been 64 feet, instead of 84 feet as noted in the table.

The change noted between any two years is not a good indication of the amount of recession or advance which may have taken place, as the local weather conditions, rainfall, and even the condition of the crevasses above, all have a marked influence in determining changes, and it is only when these are eliminated by including a longer interval that the true amount of change may be determined.

Flow of Glacier above Tongue.—In 1899, to determine the rate of flow of the ice at a point about 1,300 feet above the tongue, eight plates were laid out across the glacier. These were accurately placed by means of a transit in a true line almost at right angles to the direction of flow, and their change in position accurately determined after stated intervals. The positions of these plates have been plotted on the map, and the table on page 572 gives a summary of the changes that have taken place at the times noted.

With the exception of the comparisons made between July 31 and September 5, 1899 (see first part of table, page 574), the motion indicates the movement of the glacier over the period of approximately a year, and thus includes both the summer flow which should be greater and the winter flow which should be less than the averages given.

Several of the 1899 plates have been lost from one cause or another,

ILLECILLEWAET GLACIER.

Table Showing Motion of Line of Plates, 1899 to 1906.

Number of Plate.	Position of Plates on July 31, 1899.	Distance below original line on August 6, 1900.	Daily motion, 1899 to 1900.	Distance below original line on August 26, 1902.	Daily motion, 1900 to 1902.	Distance below original line on August 28, 1903.	Daily motion, 1902 to 1903.	Distance below original line on July 12, 1906.
1.....	On line.	1,044 ins.	2.82 ins.	3,456 ins.	3.21 ins.	Lost.	——	Lost.
2.....	On line.	1,488 ins.	4.00 ins.	4,446 ins.	3.94 ins.	Lost.	——	Lost.
3.....	On line.	1,716 ins.	4.64 ins.	4,848 ins.	4.18 ins.	6,216 ins.	3.73 ins.	On border moraine.
4.....	On line.	2,112 ins.	5.71 ins.	Lost.	——	Lost.	——	10,200 ins.
5.....	On line.	2,220 ins.	6.00 ins.	5,850 ins.	4.84 ins.	7,740 ins.	4.87 ins.	Lost.
6.....	On line.	2,280 ins.	6.16 ins.	6,312 ins.	5.51 ins.	8,388 ins.	5.65 ins.	Lost.
7.....	On line.	2,160 ins.	5.84 ins.	6,504 ins.	5.79 ins.	Lost.	——	Lost.
8.....	On line.	2,040 ins.	5.51 ins.	Lost.	——	Lost.	——	Lost.

while others have completed their journey and now rest on the bowlders at the edge of the ice. In 1906 an entirely new set of six plates was prepared, and on July 12 they were laid out on the exact line used in 1899 (see map). Some defects having been found in the first plates the ones laid out this year were of different design. A lighter steel reduced the weight by one-half without decreasing efficiency, while the pipe caulk was dispensed with entirely, a hold in the ice being obtained by turning the right edge up one-half inch, and the left edge down a like amount. The plate was thus held in position on the ice should it turn over. It is made up of but one piece, and may be nested compactly for carrying. Steel one-eighth inch thick was used, 6 inches by 7 inches, which was left 6 inches square after the edging up had been completed. A trial showed that the thinner plate, allowing greater melting of the ice beneath, formed a pocket in which the plate rested, almost entirely free from slipping even on the steeper slopes. Each plate was marked "VAUX, 1906" in white on a red lead background. The plates laid out were numbered from 1 to 6, beginning on the right side of the glacier.

The aim of this investigation was to compare the yearly rate of flow at the line laid out with the yearly changes in the position of the tongue, and to determine the effect which a change in one would have on the other. As the second series of plates have been in position but a short time no yearly comparisons can be made, but the following table, comparing the daily motion of the plates in the fall of 1899 (compare *Proc. Acad. Nat. Sci. Phila.*, 1899, p. 507) with the motion of those in 1906, will give a ratio of the summer motion between the two dates. The plates have been grouped according to their location on the glacier, the numbers in the two instances bearing no relation to each other.

The great uncertainty of this work may be realized when it is noted that in 1906 during twelve days the surface conditions of the glacier changed completely. Crevasses opened, others closed, and plates which when laid out were on comparatively level ice were found to be in almost inaccessible positions, which took long détours from the main path to reach.

The interval between the laying out and measuring of the plates was one of unusual heat. Great freshets were reported all through the district, every glacier stream was swollen to abnormal size, and evidences of great surface melting were everywhere apparent.

In addition to locating the position of the plates, a cross-section of the surface of the glacier at this point was developed. A comparison

of this area with that similarly plotted in 1899 shows a marked shrinkage in the surface of the ice at that point.

Table Comparing Summer Daily Motion of Plates on Illecillewaet Glacier. 1899–1906.

1899—36-day interval.			1906—12-day interval.		
Number of Plate.	Feet from 1906 ice edge.	Average daily motion in inches.	Average daily motion in inches.	Feet from 1906 ice edge.	Number of Plate.
			Plate lost.	92	1
1	187	2.56			
			7.00	276	2
2	415	3.90			
3	520	5.51			
			11.33	532	3
4	668	6.77			
			9.75	727	4
5	760	6.06			
6	900	6.79			
7	956	6.16			
			10.25	1,020	5
			8.85	1,171	6
8	1,220	6.00			

Asulkan Glacier.

Glacier House, British Columbia.

This glacier, lying at the head of the Asulkan Valley, some three miles from Glacier House in British Columbia, has been observed with more or less regularity since 1899 (compare *Proc. Acad. Nat. Sci. Phila.*, 1899, p. 504). At that time rocks were marked and the general aspect of the tongue and moraines noted. Photographs have also been made which show the yearly changes in extension, thickness and breadth.

The work on this glacier in 1906 covered practically the same ground as on the Illecillewaet, and may be similarly divided.

Test Pictures.—An almost continuous record of photographs of the lower section has been made since 1899 from a large flat rock several hundred feet below the glacier which affords a view of all parts. A comparison of these photographs taken over a series of years shows smaller changes than in the cases of some of the neighboring glaciers, but that they are of the same character—a general shrinkage and reduction of section area (compare Plates XXV and XXVI with Plate VI, *Proc. Acad. Nat. Sci. Phila.*, 1899).

Changes in the Tongue.—On the left side the Asulkan Glacier is bearing a large amount of morainal material which is deposited at the lower part of the left edge and upon the tongue. The right side is comparatively free from moraine except stray erratics which are borne on the surface of the ice and deposited at the edge. Several small moraines on the bed moraine indicate that at one time the amount of this material was much greater than at present.

For several years the tongue has been deeply bedded in moraine and was difficult to locate. During the period of slight advance which was first noted in 1903 a steep moraine was pushed up at the tongue and the stream forced to find an exit through a smaller moraine on the right. The present year, however (1906), the tongue occupied almost exactly the same position as in 1899, leaving a space between the ice and the moraine which was formed during the glacier advance. A considerable stream issues directly beneath the tongue and almost covering the 1899 test rock, has broken through the high unstable moraine.

The following table shows the changes in the tongue as observed since 1899.

Table Showing Changes in Tongue of Asulkan Glacier.

Aug.	12, 1899	"Rock opposite lined with snout."
Aug.	8, 1900	Snout receded 24 feet.
Aug.	6, 1901	Ice *above* rock 20 feet, 4 feet advance.
Aug.	30, 1903	Ice *below* rock 16 feet, 36 feet advance since 1901.
July	23, 1906	Ice lines with test rocks, or is in same position as in 1899.

The Flow of Glacier above Tongue.—For this work a line was selected across the glacier about 1,250 feet above the tongue and as nearly as possible at right angles to the line of flow. Owing to the comparatively short distances and the ease of observation no base line was laid down except as a check, and the positions of the plates from the points of observation were determined by means of the stadia. The motion of the plates on the ice was in every case measured with a horizontal steel tape at right angles to the base line. Plates numbered 7 to 12, similar to those used on the Illecillewaet Glacier, were laid out on July 13, 1906, and their motion determined on July 23. The following table shows the total and average daily motion of the plates and of a very large oblong bowlder resting on the top of the moraine on the left edge of the glacier and advancing with it.

Table Showing Average Daily Motion of Plates on Asulkan Glacier between July 13 and July 23, 1906.

Plate.	Total Motion.	Average Daily Motion.	Remarks.
No. 7	24 in.	2.4 in.	Near right edge of ice.
No. 8	39 "	3.9 "	63 feet from R. edge.
No. 9	55½ "	5.5 "	157 feet from R. edge.
No. 10	67 "	6.7 "	325 feet from R. edge.
No. 11	67 "	6.7 "	415 feet from R. edge.
No. 12	63 "	6.3 "	Close to left edge.
Bowlder	89 "	8.9 "	On left moraine, resting on icefoot.

Sketch Map of Tongue.—The accompanying map of the glacier foot has been compiled from a series of stadia measurements, sketches and photographs. On it have been plotted the position of the tongue and the outline of the ice as it existed on July 23, 1906. If question is raised as to the accuracy of the stadia method for this class of work, it may be noted that in every instance the motion of plates and recession were determined from measurements with a standard tape, and it was found that over rough ground and glacier surfaces work could be greatly expedited by use of the stadia, with an error not so great as would be encountered on the necessarily small scale of the plotting map.

Wenkchemna Glacier.

Valley of the Ten Peaks, Laggan, Alberta.

In some respects this glacier presents the most unusual aspect of any noted in the region. Of the piedmont type its névé receives snow which falls and is blown across the Wenkchemna Group or "The Ten Peaks" and falls into the couloirs and chimneys lying on the northern slopes. At the lower levels a number of comparatively small glaciers are formed, flowing almost due north across the southern half of the Valley of the Ten Peaks. The valley bottom in places is covered with an open forest of firs and spruces, the Lyell larch being found in abundance at the upper (western) end where an elevation of over 7,000 feet is reached.

At the head of the valley several almost parallel lines of ancient moraines were noted, and distinct traces of them could be followed down the valley till they were finally lost in the stream-eroded bottom. These moraines, and the very interesting one at the lower end of Moraine Lake which has given it its existence and name, point clearly to the

fact that the glacier at one time covered the entire bottom of the valley, and that the medial moraines which are now noted between the several sections of the glacier were at that time carried entirely on its back down the valley and deposited far below, without leaving any trace of the route which had been originally taken.

It has been known for a number of years that some portions of the Wenkchemna Glacier were advancing, or rather that from time to time masses of moraine which had rested almost upon the limit of the ice had been shot down upon and partly or completely covered living trees of the forest, which in places comes directly up to the ice wall. A comparison of photographs taken in previous years with the conditions as they were found in July, 1906, indicated that at the points in question no material advance of the ice could have taken place, and yet at these very points there was evidence of masses of moraine being projected on the ground below. The fresh rock was thrown beyond the limit of the ice, which to all observation had not changed recently. The base of the glacier close to the ground gave evidence of not having changed for a number of years, but from the ice slope above masses of rock were and had been precipitated *over* and beyond the older rocks and upon the grass and trees.

A careful consideration of these unusual conditions seemed to offer but one satisfactory solution. The ice forming this glacier, or rather composite glacier, is largely contained in a hollow or basin, from the bottom of which drainage is provided to the lake below. The ice extends above the edges of the basin, in many places covered deeply with moraine. The pressure upon the ice from behind causes a slow but steady motion of the upper strata towards the edges, which sets up a *shearing* action of one layer of ice on that below. The result is that the upper part of the moraine, very thin and unable to withstand the pressure, is pushed outward by the ice till it falls over the edge of the lower and more stable portions and upon the green grass or forest beyond the limits of the basin. It is evident that this action is much more active at certain points than at others, and an attempt was made to determine whether the position of the edge had anything to do with it, without satisfactory results.

Whatever may finally be determined as to the cause of change in the ice edge, a tramp over the glacier surface gave many evidences of great and continued shrinkage. The moraines everywhere showed that though they had been recently formed the ice was then many feet thicker, and a series of very beautiful rock cones, which rested on the solid ground but were surrounded by ice, bore silent witness to the

immense thickness of the ice in recent times compared with what is noted at present.

Victoria Glacier.

Lake Louise, Laggan, Alberta.

Almost as accessible as the Illecillewaet, the Victoria Glacier has never received the same careful study owing in large measure to the immense moraines which bury the tongue and the almost impossible task of finding permanent base and line ends. The great boulder marked in 1899, and which the next season had moved with the ice 147 feet, has not since been measured, but the position of the ice on the northwest side, referred to several large angular blocks of red quartzite, has been repeatedly determined.

During the summer of 1898 these blocks slipped from the ice and fell to the moraine below. On July 29, 1899, they were 20 feet from the ice; on July 24, 1900, 26 feet, showing a change of 6 feet for the year; on September 1, 1903, 76 feet 6 inches, or an average yearly shrinkage of almost 17 feet, while on July 30, 1906, the distance was but 74 feet 7 inches, showing practically no change, as the early date of measurement in 1906 compared with 1903 would make considerable difference in the total figures.

Wapta or Yoho Glacier.

Yoho Valley, Near Field, British Columbia.

This glacier, located at the head of the Yoho Valley, is a very long day's trip from Field, the station on the railway. On August 17, 1901, the position of the tongue was marked on a large mass of bedrock which had been recently uncovered by the ice. The tongue at this time was a narrow blade of ice somewhat to the left of the axis of the glacier and lying in a long deep groove between parallel ledges of rock. Three years later the change was measured on August 7, 1904, as 89 feet, or an average yearly recession of almost 30 feet. At this time there were signs of great activity and marked shrinkage.

On July 15, 1906, almost a month earlier in the season than on the occasion of the previous visit, the glacier was again observed and the distance measured as 76 feet 7 inches, or about 12½ feet less than in 1904. Allowing for the earlier date, it may be said that the tongue is in the same position as two years ago. The general aspect of the ce showed that it was shrinking and retreating, and this was particularly

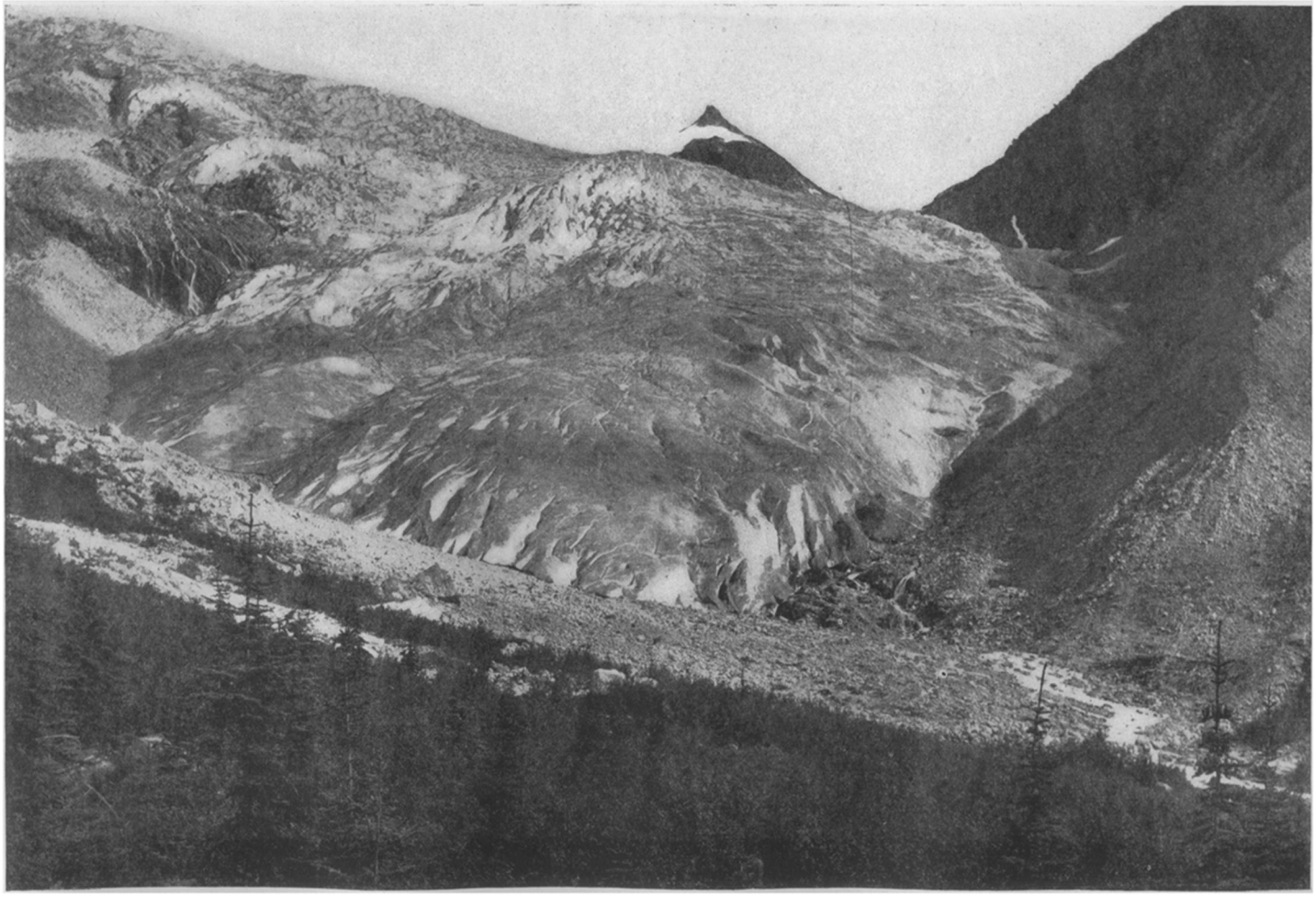
the case on the right side where the main stream debouches from a most beautiful ice arch.

Horseshoe Glacier.

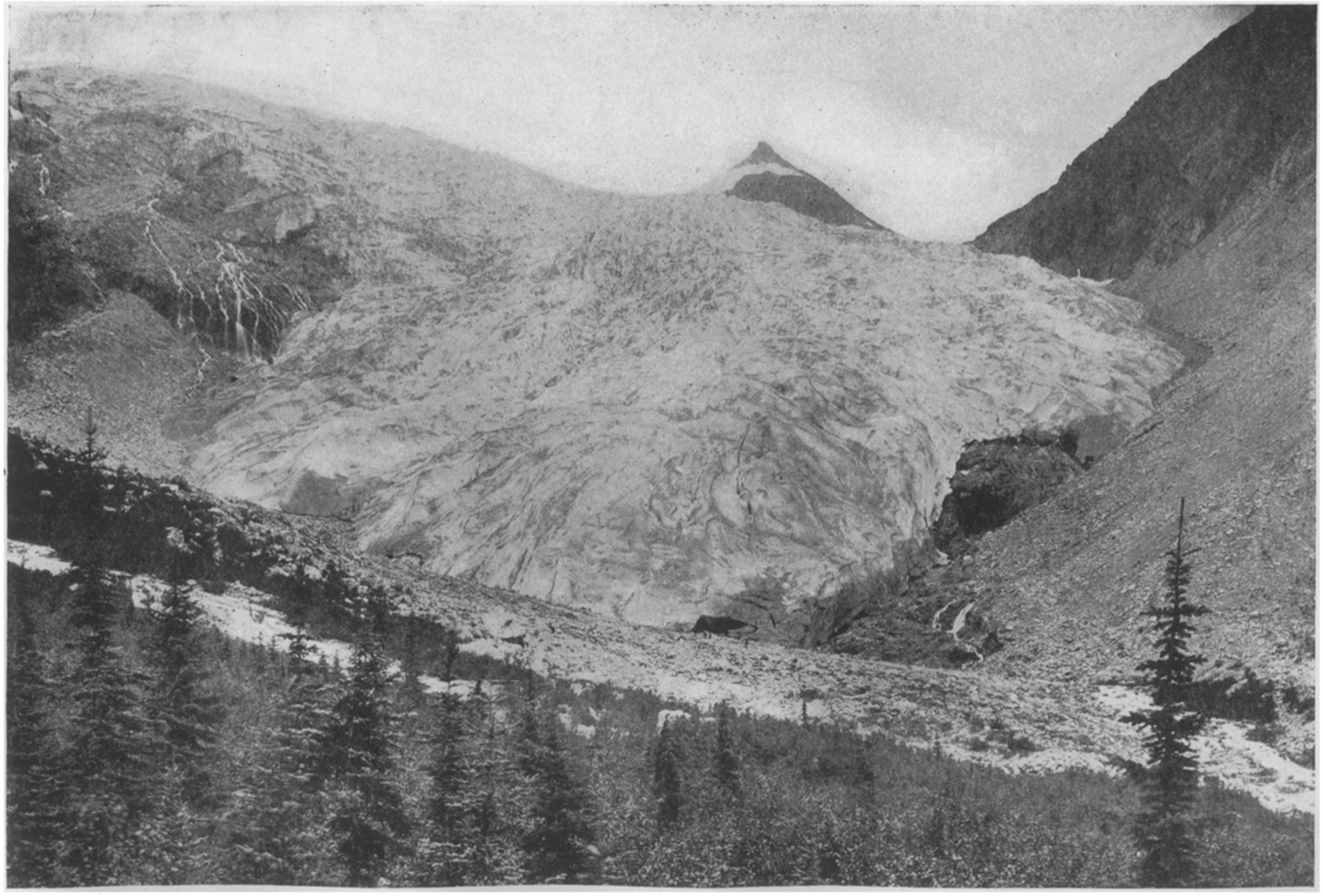
Paradise Valley, Laggan, Alberta.

Although no marks have been placed on this glacier it offers some striking and unique points of interest. It is of the piedmont type and owes its existence to the snow avalanches from Mounts Hungabee, Ringrose, Lefroy and Mitre, to the north of which it lies. . The tongue and lower portions are deeply buried in moraine. While in common with others there are indications of shrinkage and retreat, the protection of moraine on the surfaces renders these changes very slow. An exceedingly interesting phenomenon was noticed at a point several hundred feet above the tongue where a great sinuous cañon has been worn in the ice. The sides were perpendicular or overhanging, from 20 to 30 feet in depth, while the curves were 1,000 to 1,500 feet long. In all there were not less than ten great bends, and through the bottom a good-sized stream flowed. The walls exhibited very fine examples of banding, while all the surfaces were fluted horizontally, apparently due to the greater melting in summer than in winter. Should this be correct the cañon has been at least twelve years in forming.

From the foregoing data it is hard to draw more than the most general conclusions. It may, however, be safely noted that in all the glaciers observed there has been decided shrinkage and recession in the past seven years. While changes in the position of the tongue may have been small, the ice mass and sectional area are evidently much less. On the other hand the average yearly recession was in 1906 less than during a similar period five years before, the exception in the Illecillewaet Glacier being probably due to unusual conditions. The trifling advances in the Asulkan Glacier may be attributed to local causes and have no particular significance, but the increased daily rate of flow of the Illecillewaet, coupled with a thickening of the ice at the sky line as seen from the test rock, would seem to point to a period of greater activity in the not very distant future.



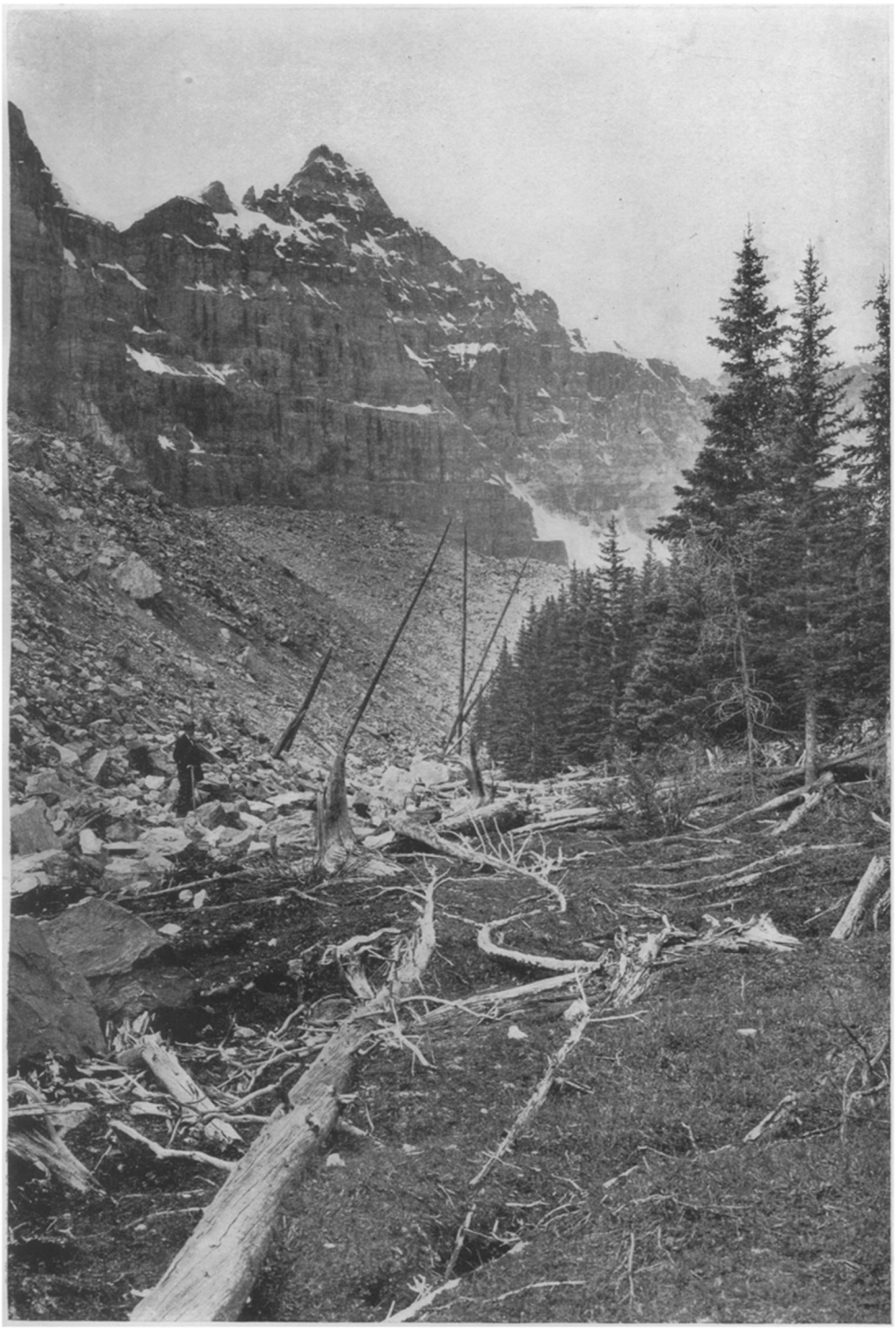
G., JR., AND W. S. VAUX, ON GLACIERS IN ALBERTA AND BRITISH COLUMBIA.
ILLECILLEWAET GLACIER, FROM TEST ROCK, 1902.
(COMPARE PL. V PROC. ACAD. NAT. SCI. PHILA., 1899.)



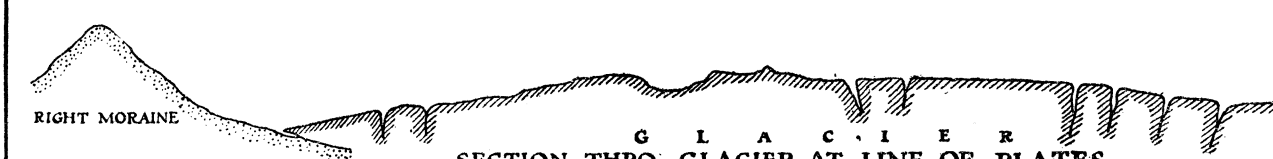
G., JR., AND W. S. VAUX, ON GLACIERS IN ALBERTA AND BRITISH COLUMBIA.
ILLECILLEWAET GLACIER, FROM TEST ROCK, 1906.
(COMPARE TEST PICTURE OF 1902.)

G., JR., AND W. S. VAUX, ON GLACIERS IN ALBERTA AND BRITISH COLUMBIA.
ASULKAN GLACIER, FROM TEST ROCK, 1902.
(COMPARE TEST PICTURE OF 1906.)

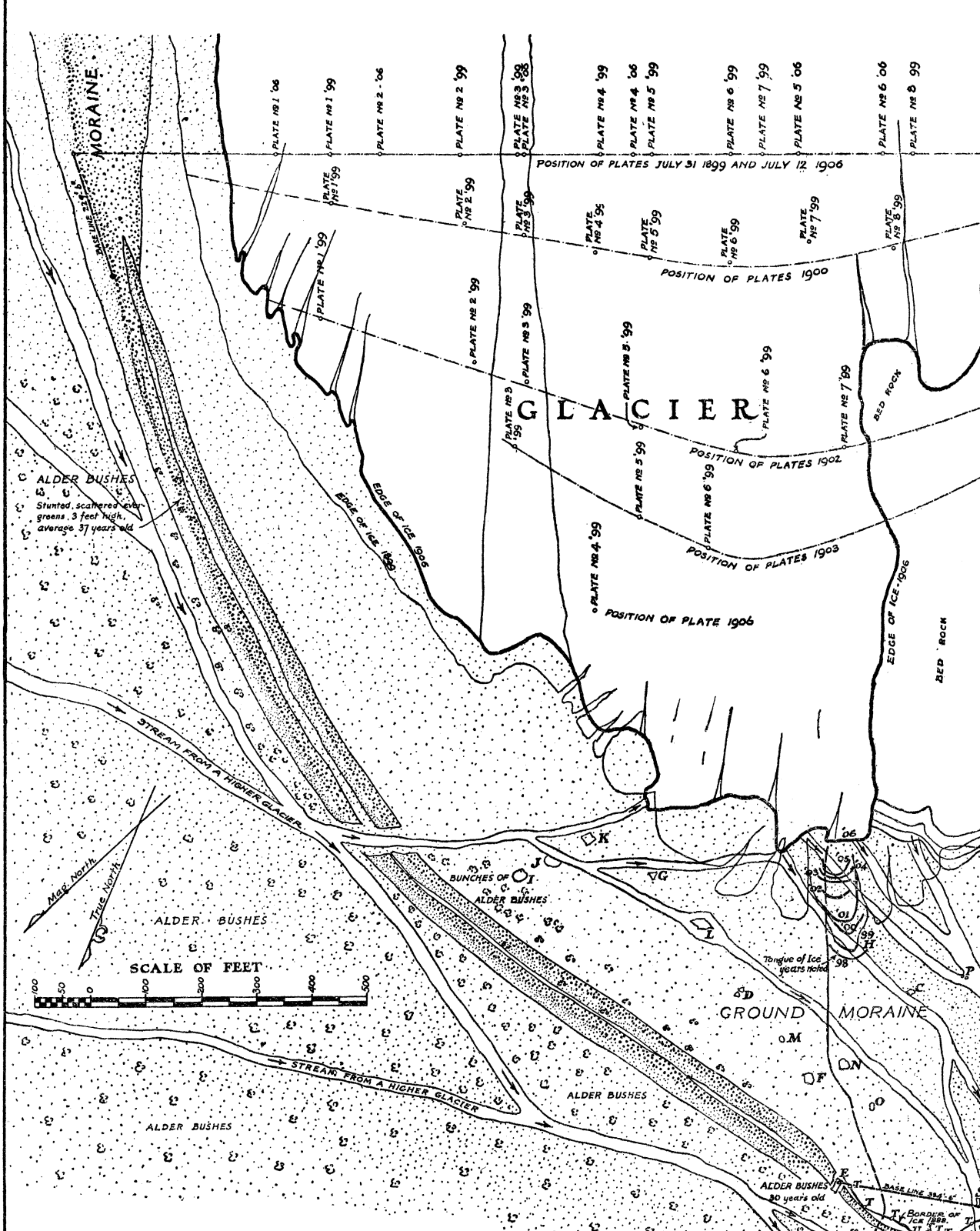
G., JR., AND W. S. VAUX, ON GLACIERS IN ALBERTA AND BRITISH COLUMBIA.
ASULKAN GLACIER, FROM TEST ROCK, 1906.
(COMPARE TEST PICTURE OF 1902.)

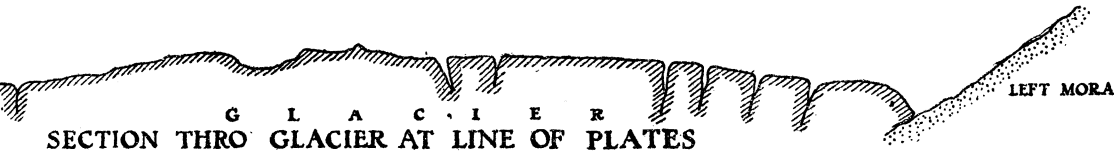


G. JR, AND W. S. VAUX, ON GLACIERS IN ALBERTA AND BRITISH COLUMBIA.
WENKCHEMNA GLACIER, ALBERTA.
(SHOWING MORAINE ENCROACHING ON FOREST.)

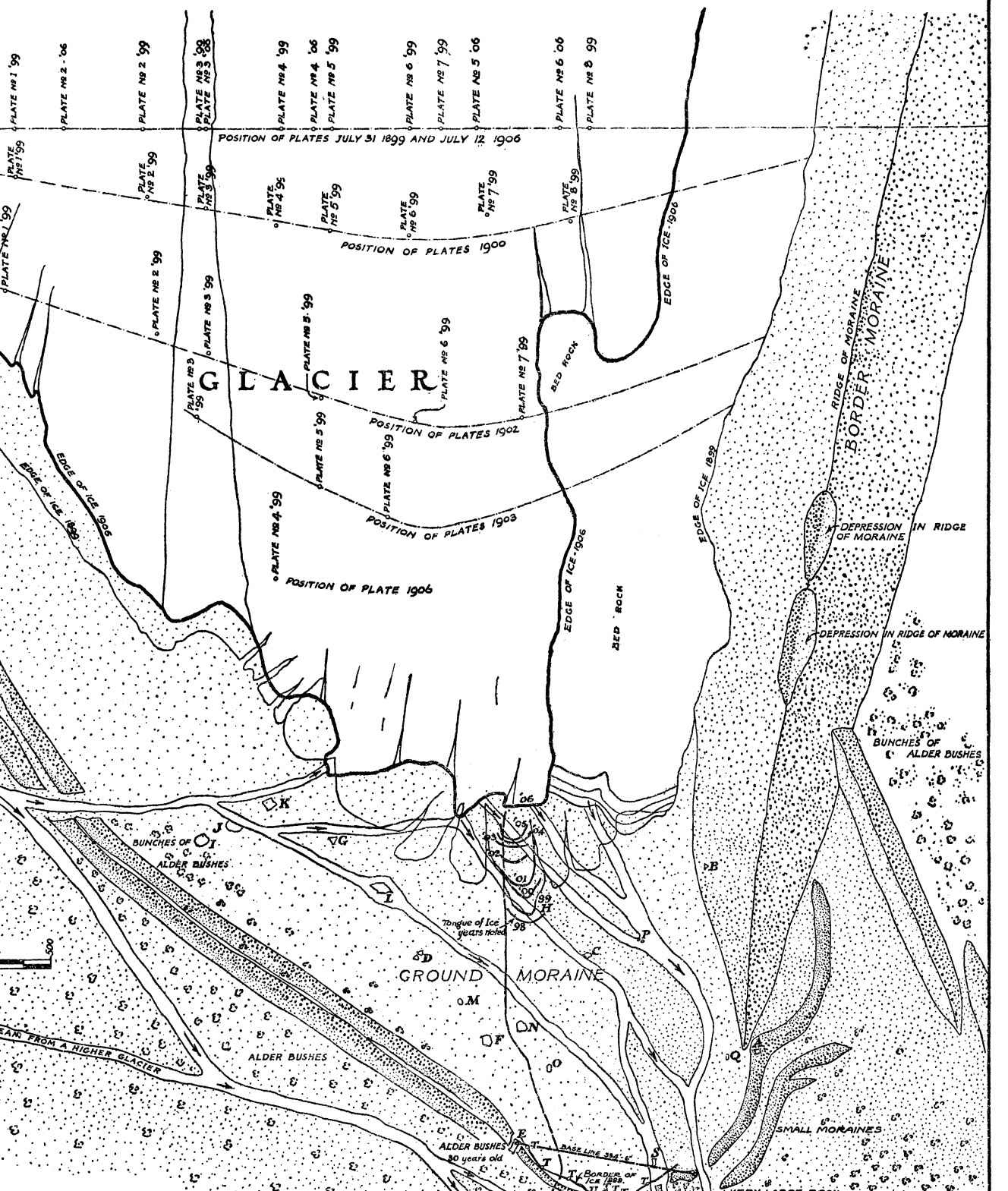


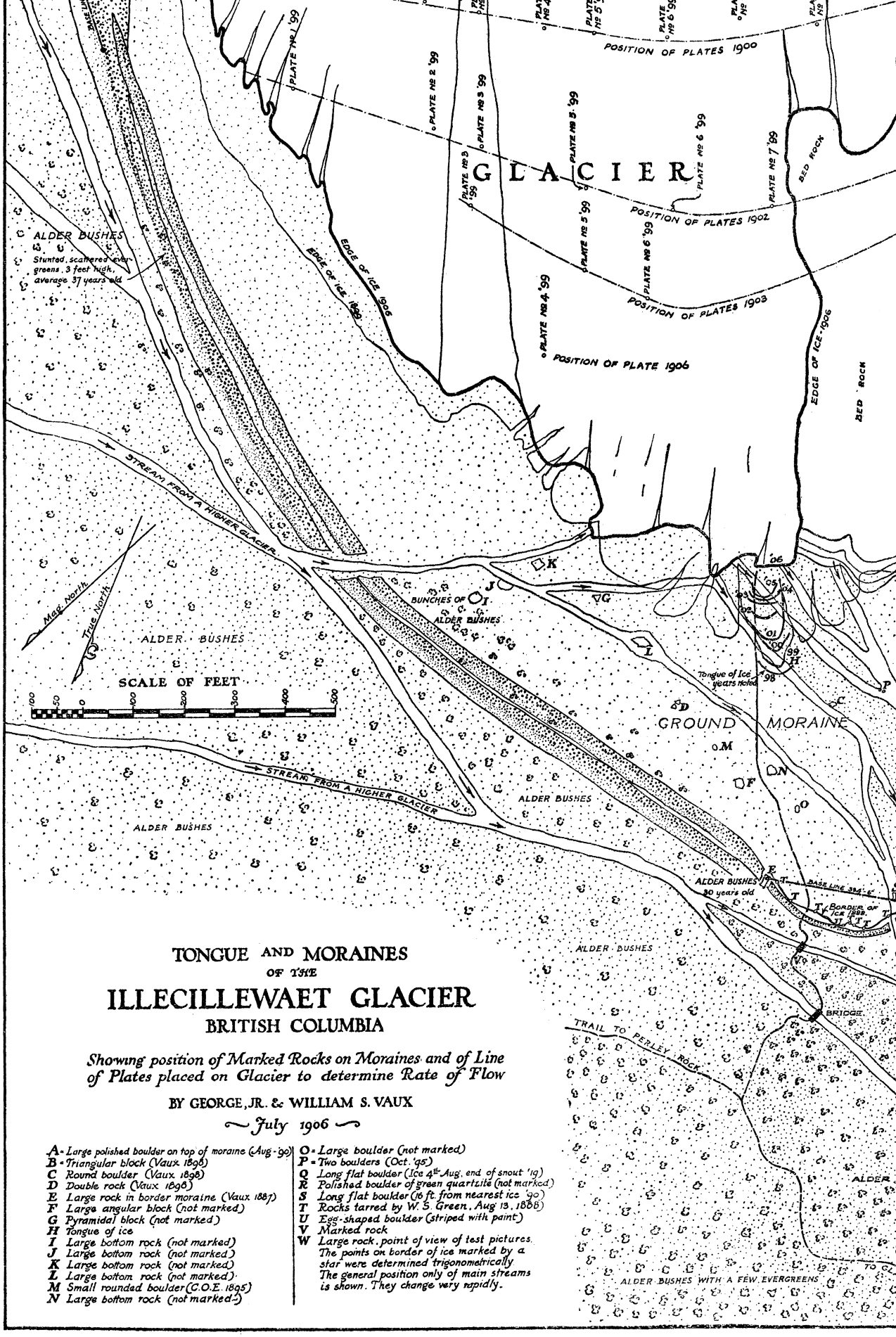
SECTION THRO GLACIER AT LINE OF PLATES





SECTION THRO GLACIER AT LINE OF PLATES





TONGUE AND MORAINES OF THE ILLECILLEWAET GLACIER BRITISH COLUMBIA

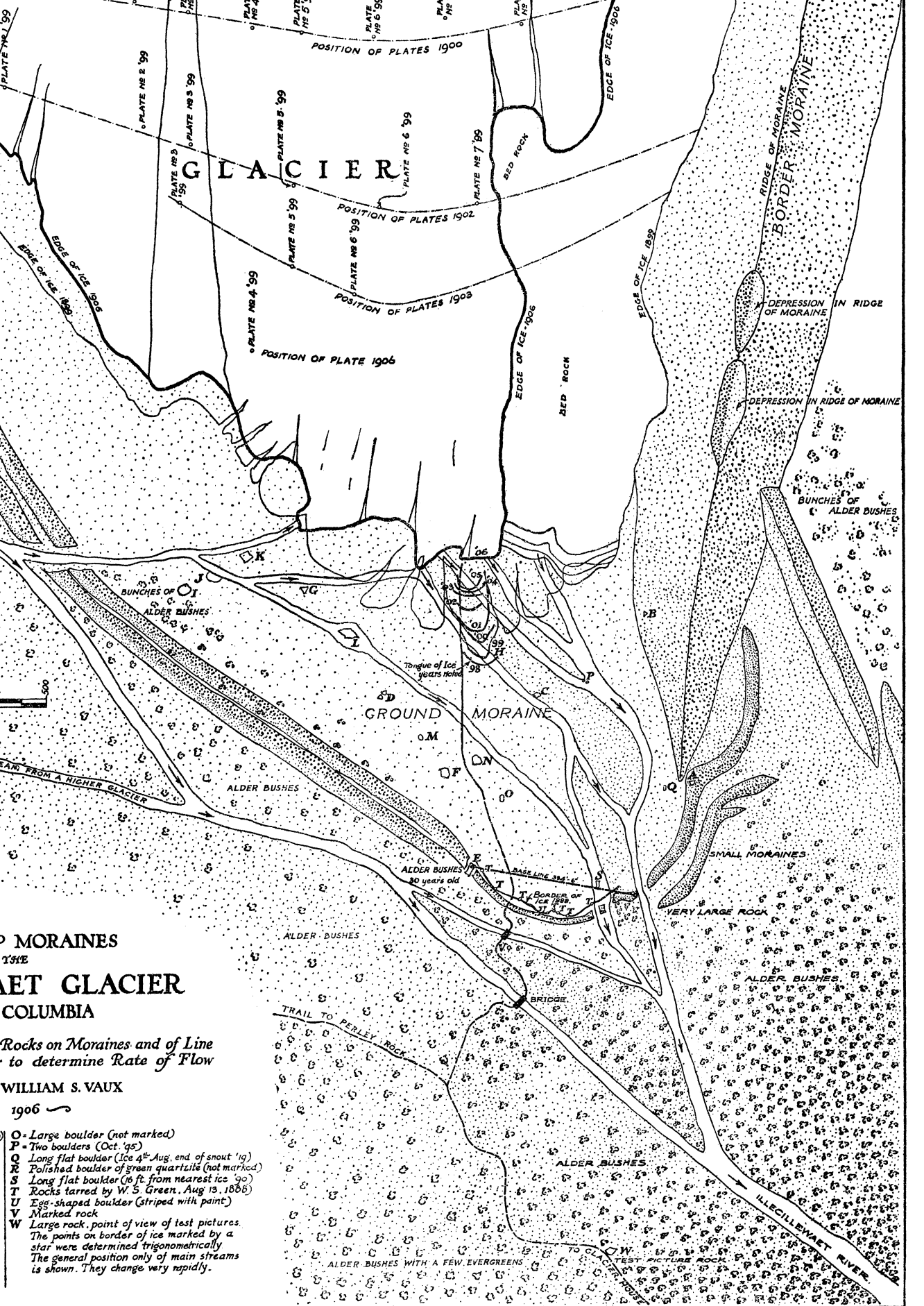
Showing position of Marked Rocks on Moraines and of Line of Plates placed on Glacier to determine Rate of Flow

BY GEORGE, JR. & WILLIAM S. VAUX

July 1906

A = Large polished boulder on top of moraine (Aug. '90)
B = Triangular block (Vaux. 1898)
C Round boulder (Vaux. 1898)
D Double rock (Vaux. 1898)
E Large rock in border moraine (Vaux. 1887)
F Large angular block (not marked)
G Pyramidal block (not marked)
H Tongue of ice
I Large bottom rock (not marked)
J Large bottom rock (not marked)
K Large bottom rock (not marked)
L Large bottom rock (not marked)
M Small rounded boulder (C.O.E. 1895)
N Large bottom rock (not marked)
O = Large boulder (not marked)
P = Two boulders (Oct. '95)
Q Long flat boulder (Ice 4th Aug. end of snout '19)
R Polished boulder of green quartzite (not marked)
S Long flat boulder (16 ft. from nearest ice '90)
T Rocks tarred by W. S. Green, Aug 13, 1888)
U Egg-shaped boulder (striped with paint)
V Marked rock
W Large rock, point of view of test pictures.

The points on border of ice marked by a star were determined trigonometrically. The general position only of main streams is shown. They change very rapidly.



P MORAINES
THE
AET GLACIER
COLUMBIA

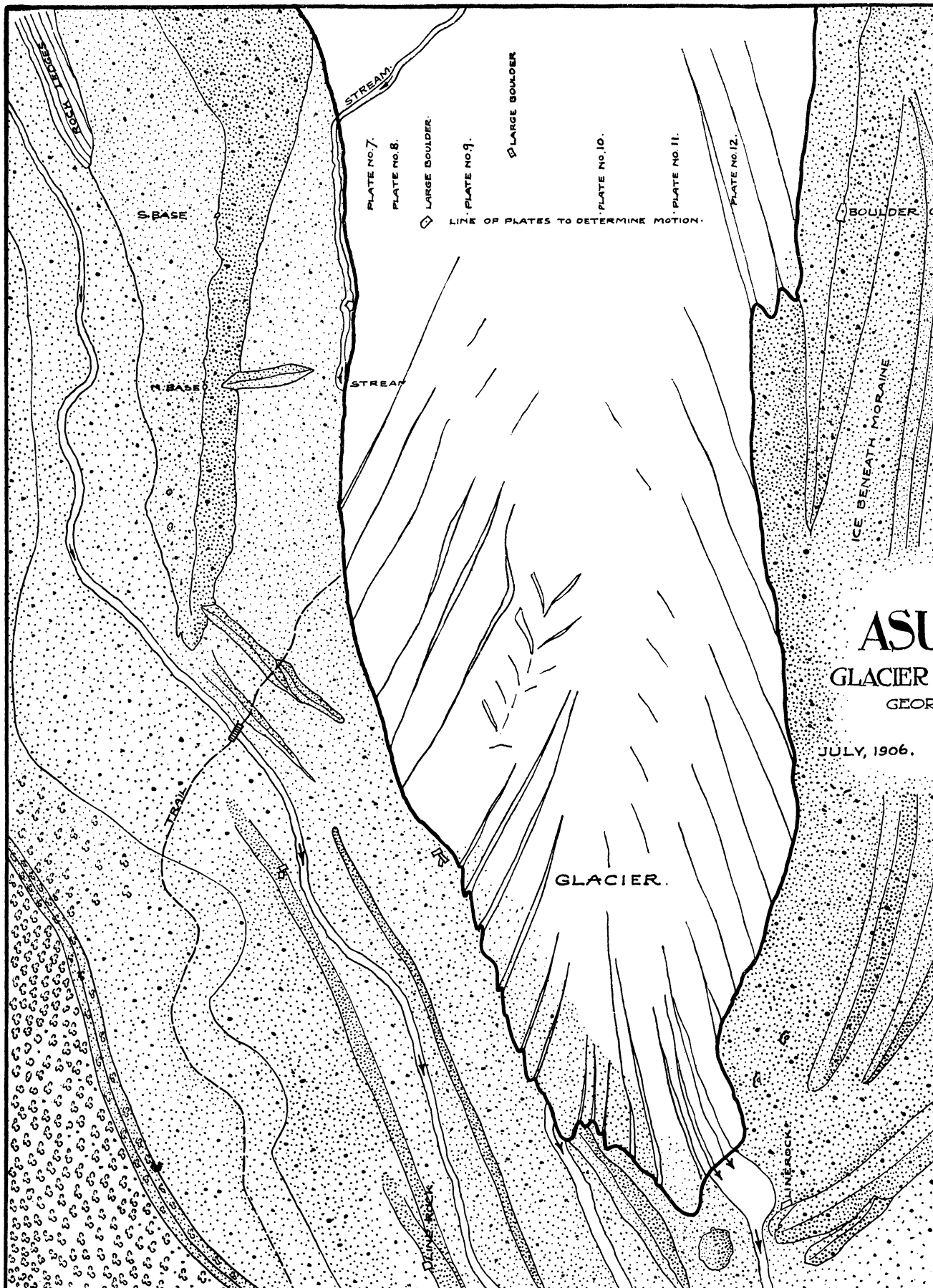
Rocks on Moraines and of Line to determine Rate of Flow

WILLIAM S. VAUX

1906

O = Large boulder (not marked)
P = Two boulders (Oct. '95)
Q Long flat boulder (Ice 4th Aug. end of snout '19)
R Polished boulder of green quartzite (not marked)
S Long flat boulder (16 ft. from nearest ice '90)
T Rocks tarred by W. S. Green, Aug 13, 1888)
U Egg-shaped boulder (striped with paint)
V Marked rock
W Large rock, point of view of test pictures.
The points on border of ice marked by a star were determined trigonometrically
The general position only of main streams is shown. They change very rapidly.

W.S.V. DEL.


ROCK LEDGES
STREAM
PLATE NO. 7.
PLATE NO. 8.
LARGE BOULDER.
PLATE NO. 9.
LARGE BOULDER
PLATE NO. 10.
PLATE NO. 11.
PLATE NO. 12.
LINE OF PLATES TO DETERMINE MOTION.
S. BASE
N. BASE
STREAM
BOULDER
ICE BENEATH MORAINE
ASU
GLACIER
GEOR
JULY, 1906.
TRAIL
GLACIER.
POINT ROCK
LINE ROCK

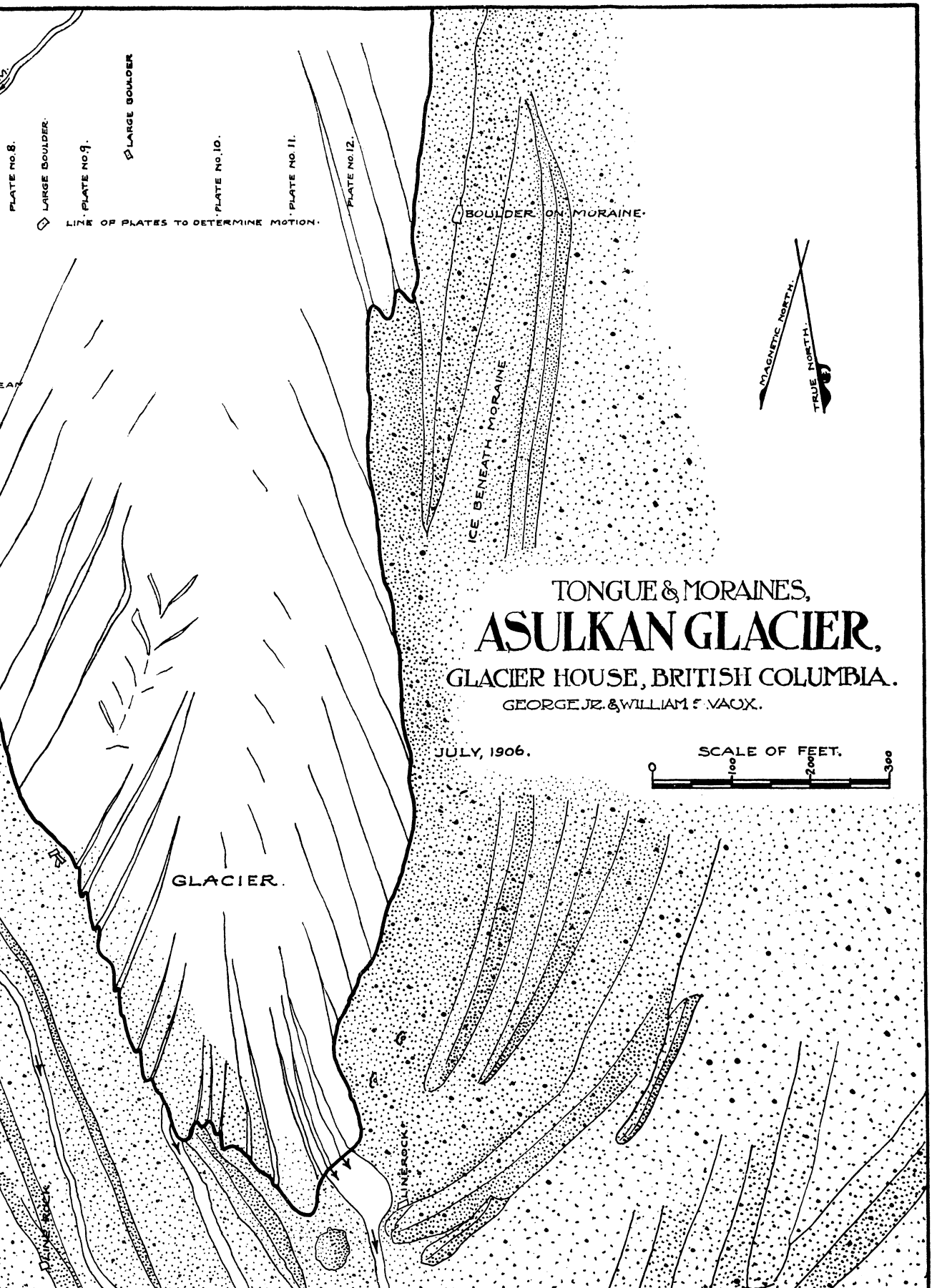
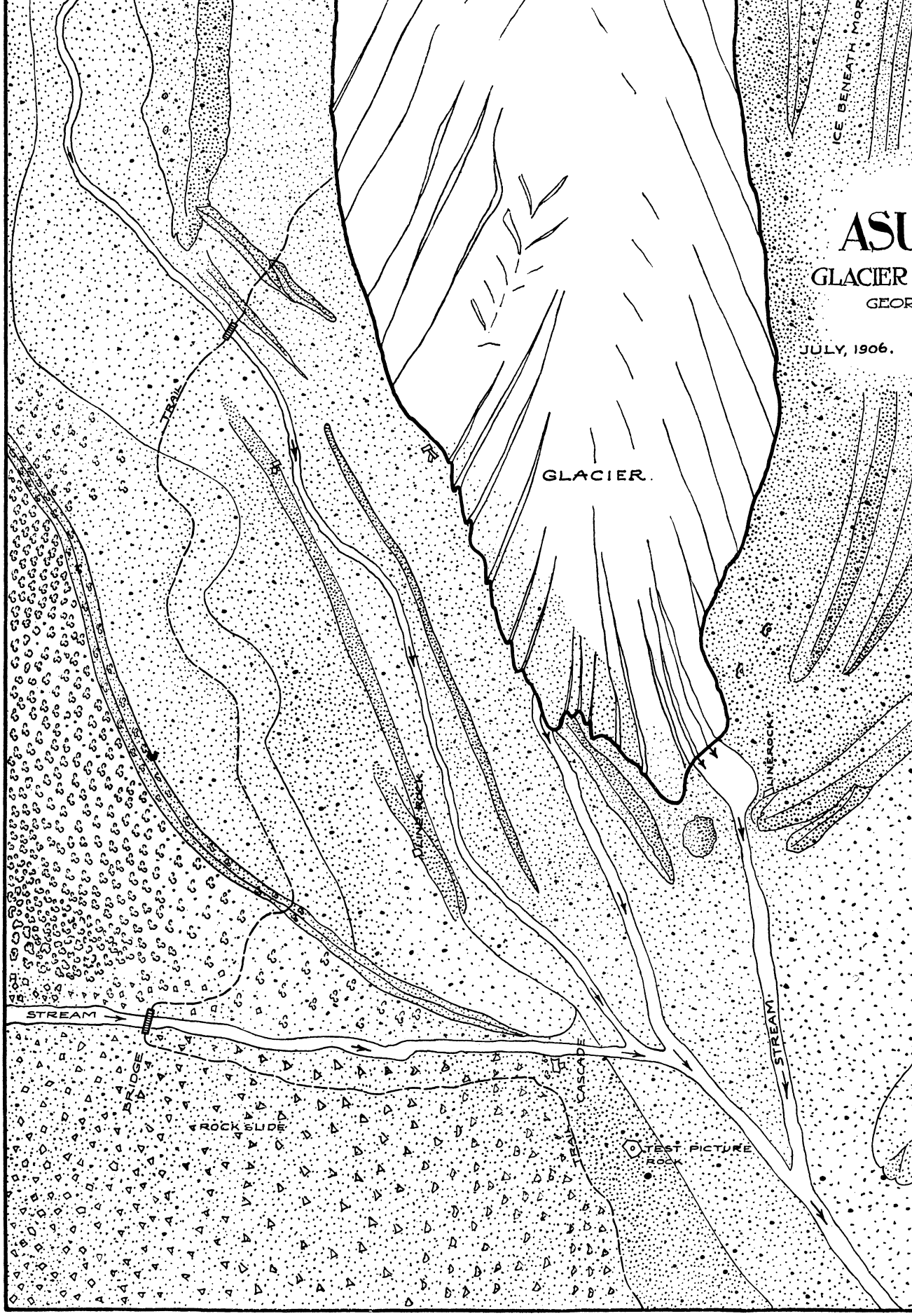
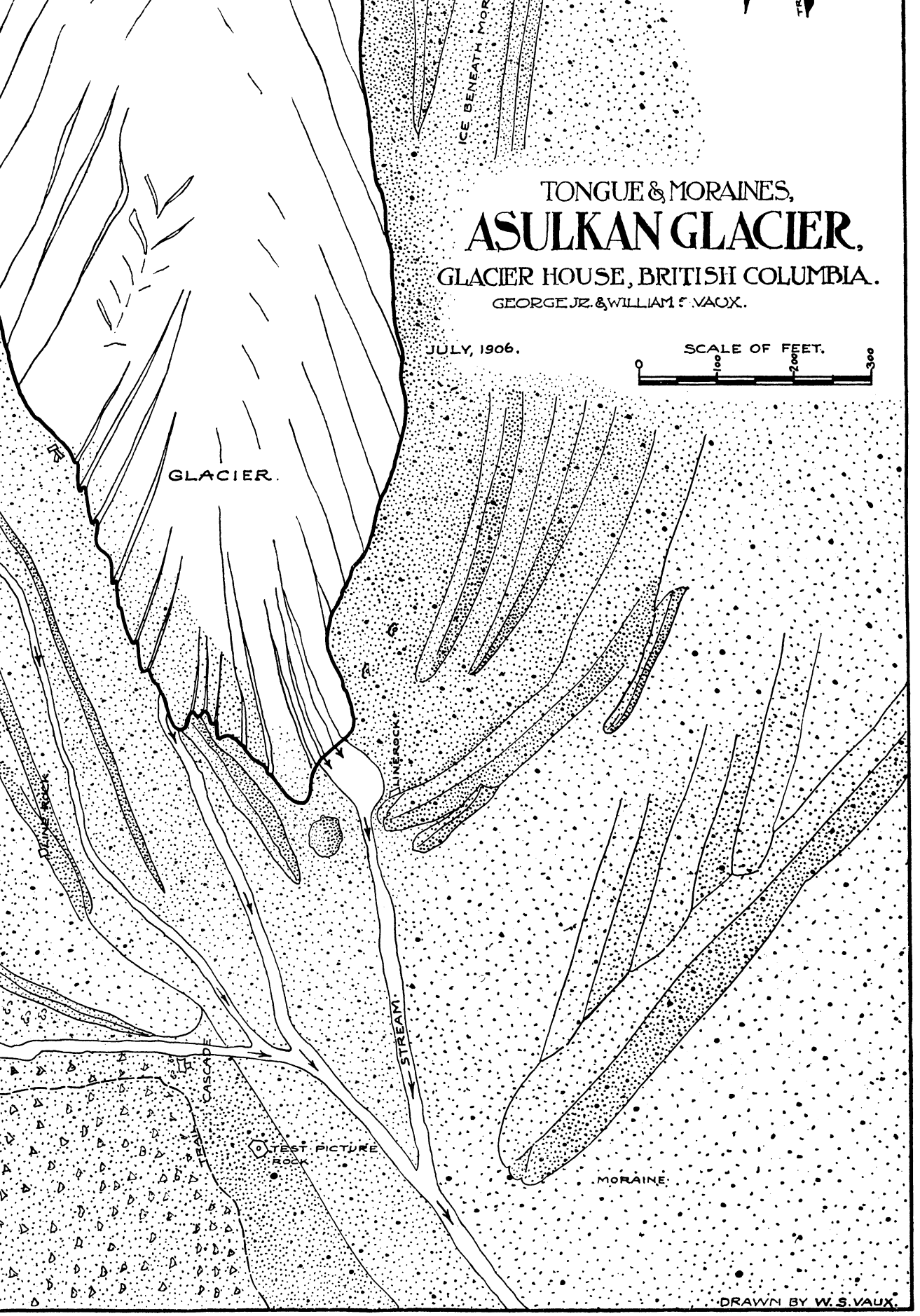


PLATE No.8.
LARGE BOULDER.
PLATE No.9.
LARGE BOULDER
PLATE No.10.
PLATE No.11.
PLATE No.12.
LINE OF PLATES TO DETERMINE MOTION.
BOULDER ON MORAINE.
ICE BENEATH MORAINE
MAGNETIC NORTH.
TRUE NORTH.
TONGUE & MORAINES,
ASULKAN GLACIER,
GLACIER HOUSE, BRITISH COLUMBIA.
GEORGE JR. & WILLIAM F. VAUX.
JULY, 1906.
SCALE OF FEET.
0
100
200
300
GLACIER.
LINE ROCK
LINE ROCK


ICE BENEATH MOR
ASU
GLACIER
GEOR
JULY, 1906.
GLACIER.
TRAIL
TRAIL
LINE ROCK
LINE ROCK
STREAM
STREAM
BRIDGE
ROCK SLIDE
TRAIL
CASCADE
TEST PICTURE ROCK


ICE BENEATH MORAINE
TONGUE & MORAINES,
ASULKAN GLACIER,
GLACIER HOUSE, BRITISH COLUMBIA.
GEORGE JR. & WILLIAM F. VAUX.
JULY, 1906.
SCALE OF FEET.
0
100
200
300
GLACIER.
LINE ROCK
STREAM
TEST PICTURE ROCK
MORAINE
DRAWN BY W. S. VAUX.